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Classroom-Integrated Movement and Music Interventions and Children's Ability to Recognize Social Interaction Based on Body Motion

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Abstract: Music and movement activities have been found to be beneficial for learning in childhood. The current study was part of the Arts@School project examining the effect of classroom-integrated arts-based interventions (music, movement, music-movement) on various student outcomes. The outcome of interest in the current report is the ability to recognize social interaction, which is one aspect of social cognition, an important but often ignored factor contributing to well-being and learning. The ability to recognize social interaction was studied using a test with two human figures either interacting with each other or moving separately. Children aged 10–11 completed the test pre and post intervention. The intervention groups and an inactive control group were four classes in a school. The interventions were delivered by teachers. The music intervention included listening, singing, and joint music making. The movement intervention was based on a creative dance approach and contained developmental movement patterns. The music-movement intervention focused on bodily experiences arising through activities combining music and movement. All intervention groups improved at the test, whereas the difference between the pre and post measurement did not reach significance in controls. This trend suggests that music and movement interventions integrated in the school learning environment may support children's ability to interpret body motion, an important aspect of social interaction.

Keywords: arts-based interventions; education; interaction; learning environments; movement; music; social and emotional learning; social cognition

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1. Introduction

1.1. Art Interventions, Child Development and Social Interaction

In recent years, there has been a growing interest within the arts field towards the potential benefits of art practices for student outcomes such as learning and well-being [1–5]. Looking at music and dance as art forms from a perspective of learning environments can be beneficial. Engaging in music activity has been found to enhance children's linguistic skills [6], verbal abilities [7], executive functioning [8] and support academic achievement [9]. Less research has been conducted on the effects of dance on children, but dance practice has been found to support children's basic reading skills [10] and improve memory and attention in adults [11–13].

From a developmental and educational perspective, not only academic skills, such as literacy, mathematics and language, but also social and emotional learning should be given attention when evaluating and investigating student outcomes. Social cognition is a very complex construct referring to processes related to the perception, understanding and implementation of cues that communicate emotional and interpersonal information [14,15]. It involves linguistic cues, but also nonverbal cues such as tone of voice, facial expression, gaze direction, body posture, movement and gestures, actions and touch [16]. Social

interaction (any verbal and nonverbal interaction that takes place between two or more individuals) is one aspect of social cognition and requires a range of motivational, affective and cognitive processes in complex dynamic interplay [17,18]. The development of social and emotional competencies is generally recognized in today's Western educational systems to be important to successful learning, well-being and functioning as part of society. Healthy social development includes these aspects, and is associated with self-confidence, good peer relationships, persistence, good language development, communication skills and attention skills, and conversely, children with early challenges in this developmental domain are at risk for a range of later personal, social and academic difficulties [19–22].

Although relatively few studies have investigated the effect of arts-based interventions on child development [5], there are some findings suggesting that both music and dance/movement activities can be beneficial for social interaction. Children attending a music school-readiness group improved more in social cooperation, social interaction and social independence scales in comparison to controls attending a no music school-readiness group [23]. Relating to empathy, a trend was found suggesting children engaged in long-term musical group interaction improved more in empathy scores in comparison to controls [24]. Even a brief intervention-like session can sometimes show immediate effects. A short session of joint music making increased spontaneous cooperative and helpful behavior between pairs of 4-year-old children, compared to children in a non-musical session to which they had been randomly assigned in an experimental setting [25].

Dance/movement activities have also been found to positively affect social interaction in children. Children from families with incomes below the poverty line who participated in a twice-a-week eight-week creative dance program (to which they had been randomly assigned) made improvements in social competence and reductions in their behavior problems compared to control children [26]. The dance program in this study [26] was based on a creative dance approach developed by dance pedagogue Anne Green Gilbert [27], encompassing a series of developmental movement patterns that typically developing children naturally move through in the first year of life. Another study found that children engaged in creative dance improved in cooperation, communication, leading, following, awareness of others and felt stronger belonging to a group, though in this study there was no control group that would have allowed for comparison [28].

From a point of view of study design, most reviewed studies used random group assignment. However, Tervaniemi et al. [5] promote the use of naturalistic real-life group allocations without randomization in this area of research because of the benefits of group allocation based on preference and motivation. Habibi et al. [29] acknowledge that the interest of both children and intervention leaders should be considered when assigning groups to art activities to maintain motivation for a longer period of time.

Regarding children with some developmental challenges, music therapy intervention was found to enhance social competence assessments in 6–17-year-olds with social skill deficits [30]. A music intervention reduced aggression and improved self-esteem in 10–12-year-olds with highly aggressive behavior compared to controls [31]. Systematic creative movement and dance activities resulted in positive tendencies in creativity and body image, as well as in motor, speech and communication in children with hyperactivity symptoms, who were selected by their class teacher to participate in systematic creative movement and dance activities, compared to a control group with the same symptoms who did not participate in any activity [32]. Children with autism spectrum disorder (ASD) are an important group to investigate. Autism spectrum disorders are characterized by difficulties in social interaction [33]. In a review, Srinivasan and Bhat [34] highlight the potential of music and movement activity to support communication and social-emotional development in children with ASD. They propose, based on the evidence reviewed, that interventions grounded in singing, music-making, joint action and social synchrony can be beneficial for relieving deficits in social communication in children with ASD.

The studies reviewed have a multitude of methods and approaches. Based on their findings, it is reasonable to assume that engaging regularly in music or dance-related move-

ment activities might have positive effects on some aspects of children's social development and social interaction.

1.2. The Body as a Source of Social Information

While much research related to nonverbal social information processing in general has been conducted on gaze following and emotion recognition through facial expression, less attention has been given to investigating social information embedded in whole body motion (review [35]). In recent decades, however, interest in this area seems to have increased, and studies have emphasized the body as an important source of social information. The discovery of the mirror neuron system [36] and subsequent extensive research in this area have revealed on a brain level how motor and sensory mirroring between individuals is an important part of understanding other people's goals and emotions, and a likely prerequisite of empathy [16,37]. The mirror neuron system is involved in both visual and auditory action recognition [38] and in understanding the intentions of other people's actions [39]. Several studies have concluded that emotions expressed through the body in different ways are well recognized by observers (review [40]). Thus, the body and its actions convey various kinds of information related to social interaction. Body motion is particularly important since interactions are dynamic.

Studies on body motion interpretation need stimuli that do not include cues from other expressive modalities to trace interpretation specifically to the movement of the body. Point-light displays, i.e., white dots on a black background indicating the joints of a moving body [41], have frequently been adopted in such studies, even though originally created for other purposes. In a point-light display, a still display resembles a random collection of dots. However, when it starts to move, a human body and its movements are immediately evident. There are no static cues, such as facial expressions, body shape or visual patterns, so perception is based on body movement. Such displays have enabled researchers to conclude that emotions are recognized from body motion depicted by dancers [42–44] from arm movements [45], gestures [46] and gait [47]. In their review, Witkower and Tracy [35] report that pride, joy, sadness, shame, embarrassment, anger, fear and disgust are all displayed and recognized through specific body movements.

Children distinguish between body motion and random motion already at an early age, as early as 3–6 months [48–51]. Typically developing children steadily improve in their ability to recognize point-light body motion, achieving a level equal to that of adults by the age of 5 years [52]. However, few studies have investigated children's ability to further interpret body motion [53].

Emotion recognition from body motion has been studied in children. Results show that 4-year-olds recognize sadness, 5-year-olds additionally fear and happiness and 8-year-olds additionally anger from expressive dance movement [42]. There is a steep increase in emotion recognition from body motion with increasing age until about 8 years, followed by improvement at a much slower rate through late childhood and adolescence [54].

Centelles et al. [55–57] developed and used a social interaction test to investigate the ability to interpret whether people are acting together from body motion. The rationale was that this ability contributes to fluent social interaction. For example, seeing people on a bus stop tap each other on the shoulder reveals a different social intention than seeing one person putting a hat on and the other tapping his mobile phone. The test consisted of point-light displays of two moving human figures, and the participant's task was to discriminate between *social interaction situations* and *no interaction situations*. In *social interaction situations* (*SI*) two humans did something together (e.g., sawing a log together), while in *no interaction situations* (*NI*) both performed their own actions (e.g., one paints, the other juggles). Centelles et al. [55,56] studied typically developing children, children with autism spectrum disorder (ASD) and adults. Typically developing children up to 8 years of age had a lower rate of correct responses than adults [55,58]. Children with ASD had a lower number of correct responses than age-matched typically developing children, suggesting that they had more difficulty discriminating social interaction situations [55,56].

The social interaction test was chosen to be used in the current study because it involves interpretation of whole-body motion, and it is well established and suited for children. Previously, test results have been reported in terms of number or percentage of correct responses (e.g., [58]). However, such a measure may be confounded by response bias. For example, if a participant prefers to respond, "yes, there is social interaction", the percentage of correct responses to SI situations is high, but at the same time there are many incorrect responses to NI situations. In order to determine participant's perceptual sensitivity without interference from response bias, the signal detection theory should be applied [59,60]: to determine sensitivity, discriminability index d' is calculated based on correct responses to SI (hits) and incorrect responses to NI (false alarms; see Section 2 for details). When two participants have equal sensitivity, i.e., ability to discriminate social interaction, their d' is the same even if one is biased to respond SI and the other is biased to NI (e.g., if the former gives 92% correct responses to SI and 74% correct responses to NI, while the latter gives 80% correct responses to SI and 89% correct responses to NI, both have the same discrimination ability with $d' = 2$). In the current study, the results of the social interaction test are given as d' since sensitivity to social interaction is of interest here.

1.3. Synchrony and Reciprocity in Social Interaction

Synchrony is an important ingredient in social interaction. Synchrony means that some events occur simultaneously or with the same timing. Another closely related term is temporal reciprocity, where actions are linked to each other in a joint temporal sequence [61]. Both occur in social interaction, as indeed, "social interactions typically involve movements of the body that become synchronized over time and both intentional and spontaneous interactional synchrony have been found to be an essential part of successful human interaction" [62] (p. 1). For example, synchrony in body sway has been shown to emerge from social interaction, e.g., when partners are discussing how to solve a puzzle, their bodies start to sway in synchrony [63]. In development, synchronization between parent and infant in terms of mutual gaze, shared attention and arousal predicts later social outcomes such as attachment and empathy [64]. Reciprocity is extremely common in social interaction, for example when handing a present to someone who takes it; there is a sequence of temporally coordinated actions enabling smooth interaction.

Synchronizing one's body with the body of another person and reciprocal actions contribute to sustaining successful social interaction [65–70]. Synchrony in pairs of point-light figures is associated with higher ratings of social cohesion [71]. Ratings of the degree of rapport manifested by a pair of walkers are the highest when they walk in synchrony [67]. Moving in synchrony enhances adults' sensitivity to other people's movements and promotes cooperative behavior [70]. Synchronous others are not only perceived to be more similar to oneself, but also evoke more compassion and altruistic behaviour than asynchronous others [72].

Moving in synchrony has been found to support bonding between groups of children, while merely moving around without synchrony in a mutual space does not have such an effect [73]. Compared to asynchronous movement, performing movements in synchrony with a peer has been found to lead to more spontaneous helping among young children; it has also been associated with increases in enjoyment, eye contact and mutual smiles between partners [74], and shown to positively influence children's cooperative behavior with a peer [24]. Pro-social effects of moving in synchrony have been noted already in 14-month-olds [75].

When looking at music and dance/movement as art forms, practicing synchrony and reciprocity—e.g., of body movement, effort, timing, rhythm, lyrics, timbre, sounds—is at the core of both. Engaging in such art forms might enhance perception of synchrony in other areas of life. Wiltermuth and Heath [76] suggest that cultural practices involving synchrony (such as music and dance) may enable groups to be more successful in coordination by strengthening social attachment. Dancing increases social bonding [77]. It has been found that adults with autism spectrum disorder who received a movement intervention based

on imitation and synchronization showed a larger improvement in emotion inference and increased synchronization skills and imitation tendencies in comparison to controls who participated in a movement intervention that did not involve these aspects [78].

It could thus be expected that music and movement interventions may foster some social skills partly due to synchronicity and reciprocity inherently involved in their practice. This could be reflected, for example, in improved sensitivity to the perception of social interaction. Specifically, music and movement interventions could be hypothesized to enhance the ability to discriminate social interaction based on body movements of two people.

1.4. Current Study

The current study was conducted as part of the Arts@School research project, one part of a multidisciplinary research initiative concerned with examining the arts as public service called ArtsEqual [79]. This Arts@School research project investigated the effects of three arts-based interventions (music MU, movement MO, and music-movement MUMO) on various student outcomes, such as mathematical skills, executive control, motivation, well-being and social cognition, in elementary school children. The rationale behind using these interventions was to investigate the effects and feasibility of increasing arts-based education in a typical school learning environment. The three interventions were based on extended music activities according to the curriculum (MU; following the curriculum by the Finnish National Board of Education, 2016), a creative dance approach to movement activities (MO; developed by Gilbert [27]) and involving movement in learning music (MUMO; based on the approach by Jaques-Dalcroze [80]). The MU intervention focused on singing, playing instruments and rhythm awareness. The MO intervention involved exercises in body awareness, mirroring and creative movement. The MUMO intervention included moving to music both by improvising and by learning movement patterns. All interventions were conducted by classroom teachers themselves, guided by experts in dance and music pedagogy. The interventions were incorporated into the regular school day three times a week.

The aim of the research reported here was to study potential effects of the interventions on the ability to recognize social interaction based on body motion. There were several other outcome measures in the research project: scholastic measures (literacy, mathematics), neurocognitive measures (executive functions, intelligence, EEG), measures of motivation and well-being as well as interviews regarding children's experiences of interventions. This limited the number and extent of single measures because of the restricted time for testing. However, it was deemed important to investigate at least one aspect of social cognition, albeit in a very condensed and brief experimental format. After a careful consideration of available measures, the social interaction test by Centelles et al. [55–57] was selected since it involved body motion and it was short and suitable for the age group. As far as the three types of interventions are concerned, they were designed based on established arts-based approaches and were predicted to have different effects on several outcomes, for example the interventions with music were hypothesized to be associated with literacy measures (based on previous research on such links, e.g., [6]), but not all outcome measures were hypothesized to differ between interventions. The other outcomes studied in the project will be reported elsewhere.

The current aim was to answer the following question: do classroom-integrated arts-based music, movement and music-movement interventions improve the ability to recognize social interaction based on body motion in school children? This was investigated using a test in which point-light displays of two people either interacting with each other or moving separately were used to measure the recognition of social interaction [55–57]. The interventions in this study were based on the art forms of music and dance and adapted to the elementary school context, but they also implicitly included different forms of practice of synchronization and reciprocity, which are key features in social interaction. It was thereby assumed that all interventions would enhance children's sensitivity to social interaction. The hypothesis was that the children who took part in the interventions (MU,

MO or MUMO) would improve in sensitivity to social interaction based on body motion more than an inactive control group.

2. Materials and Methods

2.1. Participants

Only those children who had written consent from their guardians were included as participants in the study even though entire classes participated in the interventions. Since the intervention study was conducted in one single school to have that as a fixed factor and each intervention was naturally integrated into the daily school activities by the pupils' own teacher with their own class, the downside was that anyone who did not agree to participate in research could not be replaced. Consequently, the number of participants resulted to be rather low in the participant groups reported here.

Thus, a total of 59 children took part in the study (25 girls and 35 boys). A total of 12 children (8 girls, 4 boys) took part in the music intervention (MU), 19 children (8 girls, 11 boys) took part in the movement intervention (MO), and 16 children (5 girls, 11 boys) in the music and movement intervention (MUMO). A control group of 12 children (4 girls, 8 boys) did not take part in any intervention. One girl was excluded from the MU group due to deviant data (see analysis section), leaving 11 children (7 girls, 4 boys). The mean age was 10 years 4 months (SD 5 months, range 9 years 9 months—11 years 0 months) in the MU group, 10 years 3 months (SD 4 months, range 9 years 9 months—10 years 11 months) in the MO group, 10 years 2 months (SD 4 months, range 9 years 9 months—10 years 8 months) in the MUMO group and 10 years 2 months (SD 4 months, range 9 years 9 months—10 years 11 months) in the control group in the beginning of the intervention in September. All children reported normal or corrected-to-normal vision.

The University of Helsinki Ethical Review Board in Humanities and Social and Behavioral Sciences has reviewed the study and stated that it is ethically acceptable (statement 31/2016).

2.2. Interventions

The study was conducted in a Finnish elementary school in 2017–2018 during the second year of the Arts@School research project. Out of four parallel classes in the school, three classes were assigned to one intervention each (MU/MO/MUMO), leaving one class as a control group that did not take part in any intervention. The classes were assigned to an intervention (MU/MO/MUMO/control) in agreement with the teachers to ensure both teachers' and children's motivation to engage on a long-term basis. Even if not all children participated in the study, the whole class participated in the intervention. For ethical reasons, the control group class (i.e., all children that had not been assigned to an intervention) was offered an intervention after the completion of the study.

The interventions were integrated into regular classroom teaching. Each intervention session lasted approximately 15 min and sessions were conducted approximately 3 times a week, with a total of approximately 50 sessions during the school year from September to May. They were planned through a collaboration between the classroom teachers and experts of dance and music education: professor of dance pedagogy Eeva Anttila (MO) and professor of music education Marja-Leena Juntunen (MU and MUMO).

The music intervention was conducted in line with the aims and means of regular elementary school music education. According to the Finnish music core curriculum, the aim of music education is to help pupils find personal areas of interest in music, encourage music-related activity and provide pupils with musical tools for expression, as well as supporting overall maturation and development (Finnish National Board of Education, 2016). Playful and holistic activities that provide pupils with a wide range of music styles and encourage expression of personal ideas are central to musical development in grades 1–4. Activities included singing, playing Orff-instruments, listening to music and creative tasks, such as making soundscapes, melodies and writing lyrics. Pupils were guided to learn music by ear through approaches that activate listening. A central idea

is that joint music activity fosters social skills such as respect and responsibility-taking. As the intervention followed the guidelines of the core curriculum, the students had been exposed to similar music instruction before. The intervention provided extra instruction, including extra hours, as well as extra activities (e.g., Orff-instruments, soundscapes).

The movement intervention was based on the creative dance approach developed by dance pedagogue Anne Green Gilbert [27]. It encompassed a series of developmental movement patterns that typically developing human beings naturally move through in the first year of life. These movement patterns are initially manifested through primitive reflexes and then become more and more complex and functional as the child develops [81]. Exercises were based on involving the following elements in body motion: touching the body (tactile stimulation), balancing (vestibular stimulation), proprioception and motion, e.g., paying attention to the position of limbs during motion (kinesthetic stimulation), breathing (breath enhancing), movement between the centre and the extremities of the body (centre-periphery connection), spine movement (head-tail connection), upper-lower body connection, body-halves connection, e.g., movement between right and left, and crossing the centre line of the body (cross-lateral connection). The exercises included both individual and partner-work, such as mirroring and touch. The movement intervention aimed at supporting social skills and creativity among other developmental aspects, taking into account that foundations of social interaction develop reciprocally with developmental movement patterns and body integration [27]. The movement intervention was realized without music to make a clear distinction from the music-movement intervention.

The music-movement intervention was based on the approach of Émile Jaques-Dalcroze, integrating the whole body and movement in learning music [80,82]. In Dalcroze pedagogy, learning music is approached through group activities that combine music and movement and through the bodily experiences that arise through these activities, thereby activating the pupil's whole body to sense, receive and internalize music—the body functioning as an instrument itself. In the intervention, activities included rhythmic exercises integrated with singing games and dances from different times and cultures. Body/movement exercises focused on body control, balance, motor skills, coordination and relaxation. Social objectives of the movement-music intervention included communication (e.g., ability to lead or follow), respect and ability to work with different peers in different groups.

2.3. Social Interaction Test

2.3.1. Stimuli and Equipment

The stimuli in the social interaction test were point-light displays of two human beings, originally created by videotaping movement performed by two professional actors. The stimuli have been developed and used previously by Centelles et al. [55–57].

The displays included 25 social interaction situations (SI) and 25 no interaction situations (NI), which are presented in Table 1. Examples of stimuli are presented in Figure 1. The SI situations included emotional situations (of positive or negative valence), conventional social behavior (e.g., social gestures and responses) and social activities (e.g., dancing, sports). In the NI situations, the two actors moved side by side without interacting (movements such as jumping, lifting something, skipping, stretching, walking). The actors in the NI scenes were originally filmed separately and later mounted together for the display to prevent any synchronization between actors [57].

Table 1. Point-light stimulus list. The two point-light figures are referred to here as A and B.

Social Interaction Situations (SI)	No Interaction Situations (NI)
A reprimands B who responds	A hammers a nail, B steps sideways
A and B jump up and down, playing	A turns around dancing, B lowers a rope
A and B kick a ball to one another	A jumps, B paints a wall with a brush
A comforts B who is crying	A jumps up and down, B lifts a rock
Both play a hand-clapping game together	A kicks a ball, B paints a wall with a brush
Both dance together	A wipes his/her feet, B drinks
A offers a chair, B sits down on it	A sneezes, B turns around dancing
Both wave goodbye to one-another	A opens a wine bottle, B lifts a rock
Both wave for attention and jump to greet	A plays catch, B washes dishes
A scares B and B turns and gets scared	A running, B flutters a garment
A commands B to go away, B turns away	A carries a tray, B moves to touch a wall
A curtseys for dance and B bows to accept	A painting, B juggling
Both bow to one another	A picks up clothes, B sits down on a couch
A points up and B looks in that direction	A dries her/himself with towel, B lifts shoulders
A picks up a flower for B and B takes it	A polishing shoes, B writing on a blackboard
A commands B and B gets up offended	A pulls a rope, B pours a drink
Both toast with a drink	A lifts something on a shelf, B ties a shoelace
A and B lift up one another	A stumbles, B lifts something a shelf
A tries to catch something that B has	A sits down on a couch, B plays golf
A plays music with B dancing	A does dusting, B searches for something
A gives something to B that B takes	A sweeps the ground, B attaches a poster
Both laugh at something together	A playing cello, B painting on a wall
A stumbles and B catches A	A handles laundry, B carries a tray
A serves a plate that B receives	A handles fabric, B lifts shoulders
Both see a log together	A opens a cupboard, B stretches

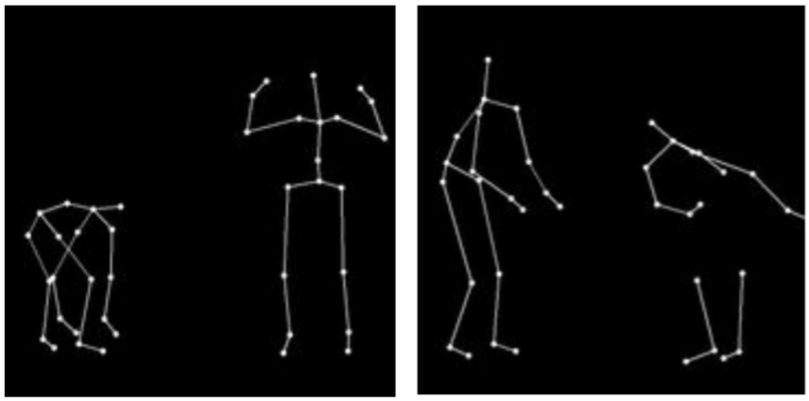

Figure 1. Examples of point-light stimuli. The images are screen-captures from test displays. Here, the two human figures are made visible with lines connecting the dots (there were no lines in the displays in the actual test). In the no interaction situation (NI) on the left, one figure ties a shoelace and the other lifts something onto a shelf. In the social interaction situation (SI) on the right, one figure curtseys for dance and the other bows to accept.

Each situation was presented twice, both as the original and as its mirror-version. Thereby, a total of 100 displays (50 SI, 50 NI) were used in the study. A total of 6 displays (3 SI, 3 NI) were used for a practice trial and the remaining 94 displays were used for the actual experiment. Each display lasted three seconds. The experiment was run on a laptop computer using a software designed for the current study using Presentation software version 20.0 (Neurobehavioral Systems, Albany, CA, USA), and a Cedrus XID Response Extension Box (San Pedro, CA, USA).

2.3.2. Design and Procedure

The child sat in a quiet room in front of the computer that was at approximately 50 cm viewing distance. The experimenter explained to the child that short videos with "dot-figures" of two people moving would appear on the screen. The child was instructed as follows: "If you think the two people are doing things together, press the left button.

If you think the two people are doing things separately, press the right button." ("Doing things together" and "doing things separately" are translated from the Finnish "toimia yhdessä" referring to two people acting/functioning/operating together and "toimia erikseen" (acting/functioning/operating separately or on their own). This was used instead of the word for "interacting" (in Finnish "olla vuorovaikutuksessa"), since this would have been too abstract a word for children of this age. The Finnish "toimia yhdessä" ("doing things together") stands well for different nonverbal and verbal interactive activities, such as dancing together, playing together, discussing and so on.)

Approximately half of the participants were asked to press the response buttons the other way around. Before the experiment, each child practiced with six displays, which were not included in the test. The test lasted approximately 15 min. It was possible to take a short break after the 20th, 40th, 60th and 80th displays. The children were tested twice, at the beginning of the school year in September (pre intervention) and at the end of the school year in April (post intervention).

2.3.3. Data Analyses

The theory of signal detection was applied in the data analysis, which enabled a separation of sensitivity from a possible response bias [59,60]. Discriminability d' reflects the participant's sensitivity, that is, the ability to discriminate the interaction stimuli from the no interaction stimuli and is not affected by response bias. The d' was calculated using the hit rate and the false alarm rate. Hits were the trials in which the participant recognized the interaction situation correctly, i.e., hits = proportion of correct responses to SI stimuli. False alarms (FA) were the trials in which the participant reported no interaction situations as interaction (NI reported as SI). In other words, FA is the proportion of error responses to NI stimuli, i.e., FA = 1—proportion of correct responses to NI stimuli. These values were normalized to obtain the z-score values z(Hits) and z(FA). The d' was calculated by subtracting the normalized values from one another: $d' = z(\text{Hits}) - z(\text{FA})$. False alarm rates of 0 were corrected using $1/2n$ and hit rates of 1 were corrected using $1 - 1/2n$, n equaling the number of trials [83].

The higher the d' is, the better the participant is at discriminating between SI and NI situations. For pure guessing (when the proportion of correct responses is 0.5 in this task with two response alternatives), d' is 0. When performance improves, d' increases approaching infinity for errorless performance. A usual range of d' scores is between about 0.5 and 4, and typical d' scores are between 1 and 2, corresponding to a proportion of about 0.70–0.85 correct responses (both SI and NI) for a bias-free participant.

For completeness of reporting, sensitivity index = discriminability d', response bias index = criterion c, measured proportion of correct responses to SI stimuli (hits) and measured proportion of correct responses to NI stimuli (which gives FA when subtracted from 1, i.e., FA = 1—correct responses to NI) are presented in Table 2 in results, even though the variable of interest was sensitivity to social interaction, d'. Criterion was calculated as $c = -0.5\,(z(\text{Hits}) + z(\text{FA}))$. Both measures were calculated using the proportion of correct responses to interaction stimuli (hits) and proportion of correct responses to interaction stimuli (FA).

The statistical analyses were conducted on IBM SPSS Statistics 28. First, the normality of the data was checked using Q–Q plots. Only one datum point deviated from normality due to an exceptionally high d' score exceeding 4, and therefore the participant was excluded from analyses.

A mixed-model analysis of variance was conducted to test for an intervention effect, i.e., whether d' increased after intervention (pre-post comparison), and whether the intervention groups (MU, MO, MUMO) differed from each other in the effect. The hypothesis that all interventions improve sensitivity to social interaction would manifest as a main effect of pre-post. If all interventions had a similar effect, there would be no interaction. Bonferroni-corrected paired-samples t-tests were then conducted to test whether all groups differed between pre and post measurements. In addition, whether responding was above

chance level, that is, whether each d' score was significantly different from 0, was tested with one-sample *t*-tests.

3. Results

The signal detection theory measures discriminability d', reflecting sensitivity to perceive social interaction, and criterion *c*, reflecting response bias, for MU, MO, MUMO and control group are presented in Table 2, as well as the mean proportion of correct responses to interaction and no interaction stimuli, for completeness of reporting.

Table 2. Means (and standard deviations) for pre and post intervention d', *c* and proportion correct for SI (social interaction) and NI (no interaction) for intervention groups and controls.

	Movement		Music		Music-Movement		Control	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
d'	1.7363 (0.5851)	2.3255 (0.6937)	1.5628 (0.7483)	2.3848 (0.8938)	1.7072 (0.6615)	2.2903 (0.7050)	1.7109 (0.3924)	1.9867 (0.4239)
c	0.2409 (0.3428)	0.3123 (0.4170)	0.1870 (0.3104)	0.1728 (0.4086)	−0.0317 (0.3596)	0.1675 (0.5199)	0.2793 (0.3731)	0.2243 (0.2902)
SI correct	0.7256 (0.1025)	0.7816 (0.1015)	0.7118 (0.1257)	0.8221 (0.1135)	0.7779 (0.1361)	0.7882 (0.1558)	0.7072 (0.1382)	0.7660 (0.1111)
NI correct	0.8365 (0.1035)	0.8953 (0.1046)	0.8008 (0.1538)	0.8699 (0.1291)	0.7806 (0.1220)	0.8853 (0.0846)	0.8511 (0.0938)	0.8759 (0.0678)

First, it was tested whether sensitivity exceeded chance level for all groups by Bonferroni-corrected *t*-tests for pre and post d' scores. All scores differed significantly from 0 (all *p*:s < 0.01, Cohen's *d*:s > 0.39). This means that children could discriminate social interaction in the test and were not responding at random.

The main interest was to investigate whether sensitivity to social interaction increased after interventions. The pre and post intervention d' for all groups are shown in Figure 2. Performance in discriminating social interaction in body motion was quite good, and improved in the post measurement, particularly for the intervention groups.

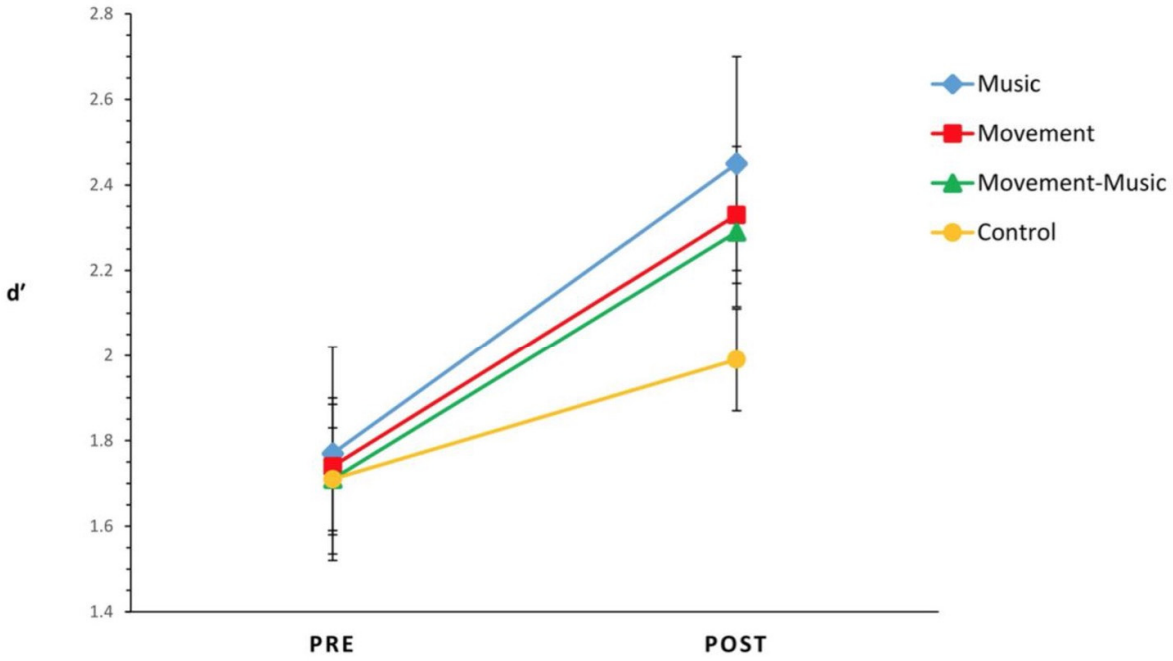

Figure 2. Pre and post intervention performance in discriminating social interaction by body motion, discriminability d' (mean and standard error of the mean), for intervention groups (MU: diamonds, MO: squares, MUMO: triangles) and controls (circles).

Since the hypothesis was that all interventions would enhance sensitivity to social interaction based on body motion, a mixed-model analysis of variance with discriminability (d') before and after intervention (pre, post) as a within-subject variable and intervention group (MU, MO, MUMO) as a between-subjects variable was conducted. There was a significant main effect of pre-post, $F(2.43) = 58.1$, $p < 0.001$, $\eta_p^2 = 0.58$, confirming that the interventions improved performance in the test. The interaction was not significant, $F(2.43) = 0.70$, $p = 0.50$, $\eta_p^2 = 0.032$, confirming that the improvement was similar for all interventions. Bonferroni-corrected paired-samples t-tests were conducted to compare pre and post intervention d' for each group. In the MU group, the post intervention d' was significantly higher than the pre intervention d', $t(10) = -4.21$, $p = 0.008$, Cohen's $d = 0.65$. This was the case also for the MO group, $t(18) = -5.05$, $p = 0.004$, Cohen's $d = 0.51$, and the MUMO group, $t(15) = -3.87$, $p = 0.008$, Cohen's $d = 0.60$. In contrast, the difference between pre and post d' was not significant in the control group $t(11) = -1.76$, $p = 0.43$, Cohen's $d = 0.54$.

4. Discussion

4.1. Ability to Discriminate Social Interaction in Body Motion and Arts-Based Interventions

The children in the current study were able to recognize social interaction from body motion, indicated by the relatively high discriminability (d'). The main research question was whether integrating arts-based music, movement and music-movement interventions in the daily learning environment could improve this ability. It was found in pairwise comparisons that d' was higher after the intervention in all intervention groups, whereas the difference between pre and post d' did not reach significance in the control group. Although these results are tentative, they imply that the interventions may have supported this aspect of social cognition, in agreement with previous findings showing that music or movement activity could support different aspects of social interaction in children [23,26,28,31,32]. Recent brain research on adults has found differences in brain activity between individuals with long-term training in dance or music and laymen [84]. The current behavioral finding suggests that effects of movement and music activity on body motion interpretation might be seen even after a relatively short period of a school year.

Interpreting body motion is an important dimension of adaptive social interaction [16,35], and healthy social development is important for well-being and learning [19–21]. Synchrony and reciprocity are key features in social interaction [62,66–69,72,85,86]. Since the movement and/or music interventions contained activities including synchronization and joint actions involving the whole body, these aspects could underlie the improvement in sensitivity to social interaction based on body motion.

Whereas the previous studies by Centelles et al. [55,56] provided valuable insight on the ability to discriminate social interaction from body motion, the data analysis in these studies produces some uncertainty to the interpretation of their results. As the total number of correct responses for SI and NI situations was used to compare performance between groups, possible response bias was not taken into account. Thereby, participants' tendency to favor either interaction or no interaction responses might have biased their scores. A strength of the current study was using discriminability d' of the signal detection theory to assess performance, and therefore the effect of possible response bias was eliminated in the data analysis.

4.2. Limitations and Future Directions

A limitation was a relatively small sample size, which was restricted by the number of same-grade pupils in one elementary school who agreed to participate in the research. On the other hand, having all participants in the same school meant that the overall everyday learning environment was similar for all pupils. The small sample size limited the statistical power, which emphasizes the need for further research with larger samples. Based on the current data, a power analysis gave a required sample size of 26 participants per group (power 0.8, effect size 0.4, significance level 0.05), which could be taken into account when designing future studies.

Furthermore, since no control activity was included in the control group, it cannot be ruled out that engaging in a joint activity as such might have supported test performance rather than the content of the interventions. Future research that includes a different type of control intervention (not music or movement) should be conducted to compare between other types of intervention. The type of joint group activities should also be investigated to find out whether arts-based activities (which could also include other art forms such as drama) are more effective than any other group activity, for example sports or games.

Very limited background information was gathered from the participants because there were several other measurements and formal assessments in addition to the social interaction test. It would have been useful to enquire about their hobbies. During interviews [87], few students reported music or dance hobbies. However, it is not possible to ascertain that hobbies related to the interventions could be a confounding factor. In future studies, more thorough background information collection is recommended.

The current study could be considered an initial step with tentative findings, hopefully encouraging further research in school-based arts interventions.

The results of the current study might be interpreted to imply that it could be useful to integrate movement and music activities in a regular elementary school learning environment to support social cognitive development. Though classroom teachers often find arts subjects challenging to teach [88,89], the current study suggests that they could successfully conduct such interventions with the help of experts.

This study also suggests that research focusing on the social development of children should consider the body as a source of social information. Social development in childhood is a complex area of research, however. Social cognition links with motivation, empathy and morality [17]. Being skillful in one domain related to social cognition does not equal overall social development. Skillfulness in interpreting others does not necessarily equal empathetic behavior [18], and sociability and social skills are different things [90]. In order to gain a more comprehensive understanding of children's social development, of which social cognition is a part, future studies would benefit from including several measures in their design, e.g., emotion recognition (body/face/voice) in combination with qualitative measures, such as self-evaluations and parent and teacher interviews, as well as metrics on children's involvement (e.g., motivation, engagement, enjoyment). The ability to recognize social interaction between two characters—as in the test of the current study—is a very specific task. It targets only a fraction of social cognition. However, in everyday encounters, this may be a useful skill since it may be beneficial to be able to interpret whether other persons are functioning together or separately, for example whether they are friends or not interested in each other. This ability might help in developing communication skills. Social and emotional learning and development should also be studied preferentially longitudinally.

5. Conclusions

Movement and music interventions were integrated in regular teaching and conducted weekly by classroom teachers in an elementary school. Out of various student outcomes, the current study examined the effect of the interventions on the ability to recognize social interaction based on body motion. The results suggest that students who participated in the interventions improved in sensitivity to social interaction. It would be important to further investigate adding movement and music activities to the school learning environment, which—among other things—might potentially have a positive influence on children's ability to interpret body motion, one aspect of social and emotional learning.

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